SFT- STATISTICAL FIELD THEORY

LOW-DIMENSIONAL SYSTEMS, INTEGRABLE MODELS AND APPLICATIONS

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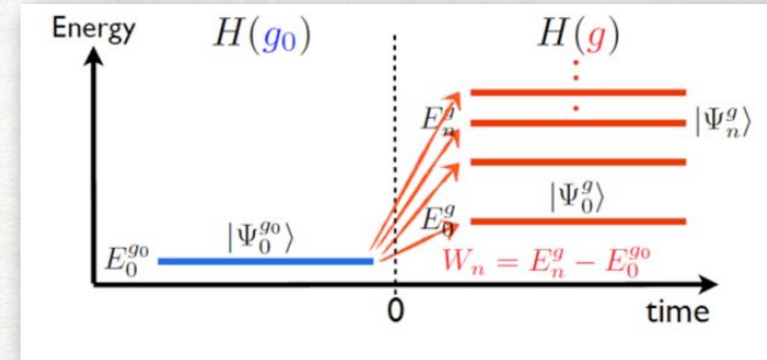
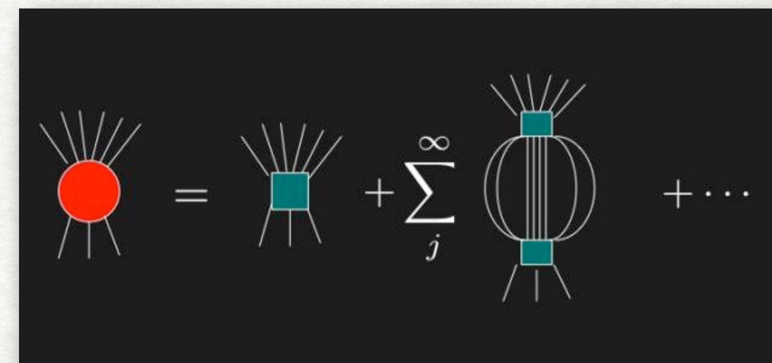
- Milano: Marco Gherardi
- Torino: Roberto Tateo
- Cosenza: Domenico Giuliano
- Pisa: Davide Rossini
- Genova: Andrea Amoretti

RESEARCH TOPICS

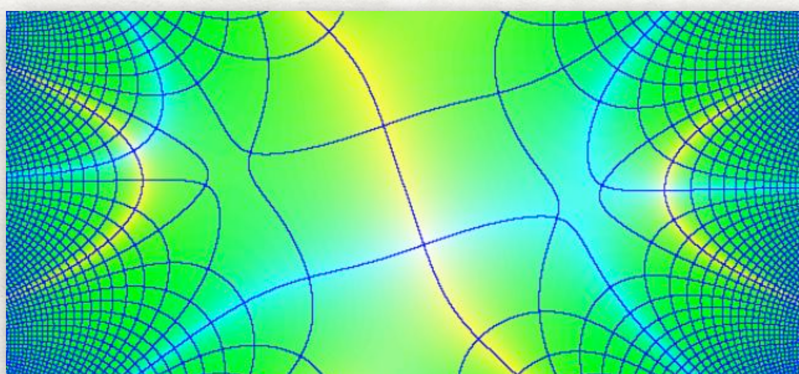
1. **Quantum field theories out of equilibrium.**
2. **Entanglement, quantum information and quantum computation**
3. **Low-dimensional quantum field theory, integrable models and deformations**
4. **Conformal invariance, conformal bootstrap and universality classes**
5. **Topological phases of matter, field theories and bosonization**



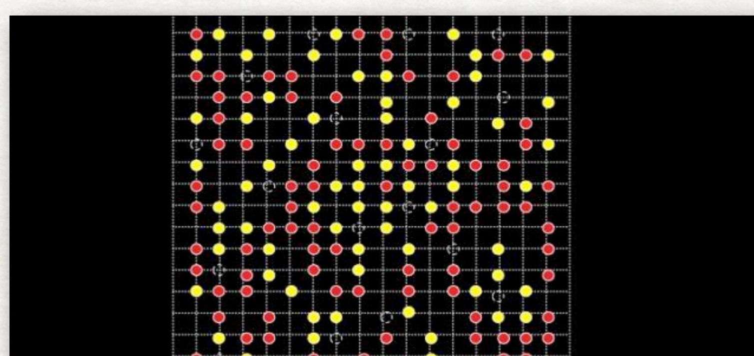
Quantum quench



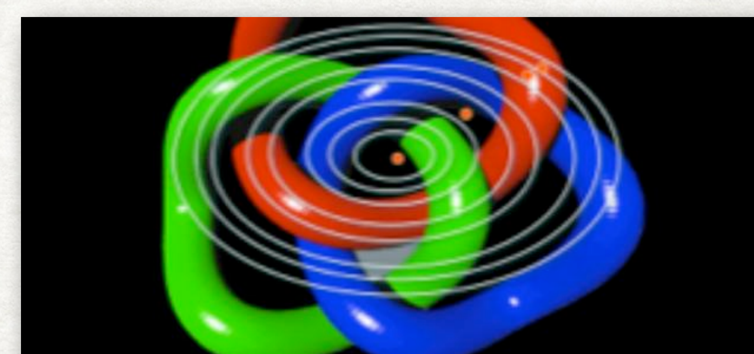
S-matrix bootstrap



Conformal map



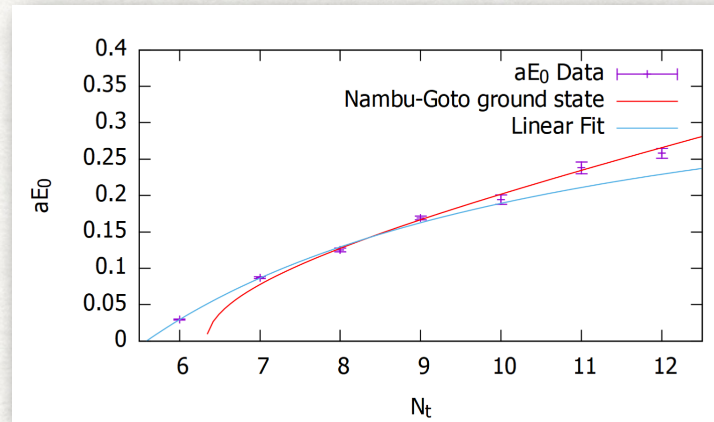
Lattice model



Topological quantum computation

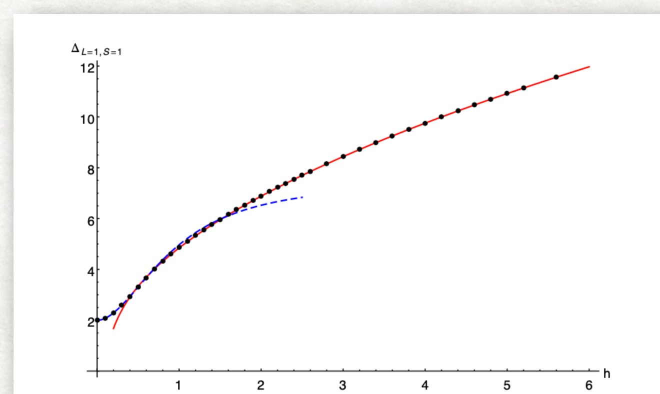
TORINO: STAFF MEMBERS

Michele Caselle:
Color Confinement and
QCD Strings
Conformal Perturbation Theory



Marco Panero:
Color Confinement and
QCD Strings
Conformal Perturbation Theory

Andrea Cavaglià:
Integrable Models
Integrability in gauge theories
Conformal Bootstrap



Roberto Tateo:
Integrable Models
Integrability in gauge theories
ODE/IM correspondence

OTHER MEMBERS

Postdocs:

Alessandro Nada: Color Confinement and QCD Strings, conformal perturbation theory.

Michelangelo Preti: Integrability in AdS/CFT and Conformal Bootstrap.

Junichi Sakamoto: 4D Chern-Simon theory and integrable models.

PdD students:

Nicolò Brizio: Integrability in AdS/CFT, ODE/IM correspondence.

Andrea Bulgarelli: numerical approach to entanglement entropy.

Elia Cellini: machine-learning applications in lattice field theory.

Tommaso Morone: Irrelevant deformations and modified gravity theories.

Dario Panfalone: SU(N) gauge theories beyond the Nambu-Goto approximation.

Lorenzo Verzichelli: SU(3) gauge theory with adjoint matter.

THE ODE/IM CORRESPONDENCE

(Related to Nicolò Brizio PhD project 1)

- It was discovered in 1998 as an equivalence between (a tower) of simple Schroedinger equations and certain conserved quantities in a quantum Conformal Field Theory on a infinite cylinder geometry.

- It evolved in a non-trivial Classical/Quantum equivalence between 2D classical integrable field theories and the finite-volume spectrum of (families) of QFTs.

The simplest example is a correspondence between the Classical and the Quantum sin(h)-Gordon model.

Classical:

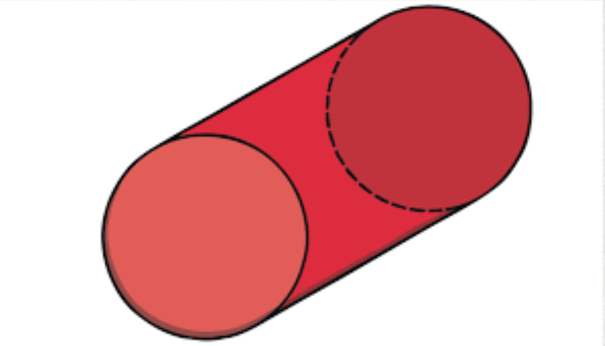
$$\partial_z \partial_{\bar{z}} \eta - e^{2\eta} + p(z,s) p(\bar{z},s) e^{-2\eta} = 0$$

(modified) Classical sinh-Gordon EoM

with potential

$$p(z,s) = z^{2\alpha} - s^{2\alpha}$$

Quantum sine-Gordon:



$$\mathcal{L} = \frac{1}{16\pi} \left[(\partial_t \varphi)^2 - (\partial_x \varphi)^2 \right] + 2\mu \cos(\beta\varphi)$$

with

$$\varphi(x+R,t) = \varphi(x,t)$$

ODE/IM claim:

For specific non trivial configurations of the classical field, the classical energy and momentum coincide the finite-size energy and momentum of the quantum sine-Gordon model

TTbar- perturbations and modified theories of gravity

(Related to Tommaso Morone PhD project 1)

Consider a family of deformations defined by the flow equation for the Action

$$\frac{\partial \mathcal{A}_\tau}{\partial \tau} = \int \mathrm{d}^d\mathbf{x}\sqrt{g}\,\mathcal{O}_\tau^{[r,d]}\;, \quad \mathcal{A}_{\tau_0} = \mathcal{A}$$

$$\mathcal{A}_\tau = \int \mathrm{d}^d\mathbf{x}\,\bar{\mathcal{L}}_\tau$$

with perturbing operator

$$\mathcal{O}_\tau^{[r,d]} := \frac{1}{d}\left(r\,\mathrm{tr}[\mathbf{T}_\tau]^2 - \mathrm{tr}[\mathbf{T}_\tau^2]\right)\;, \quad r \in \mathbb{R}\,,\; d \geq 2$$

(TTbar-type operator)

and stress-energy tensor

$$T_\tau^{\mu\nu} = \frac{-2}{\sqrt{g}}\frac{\delta \mathcal{A}_\tau}{\delta g_{\mu\nu}} = \frac{-2}{\sqrt{g}}\frac{\partial \bar{\mathcal{L}}_\tau}{\partial g_{\mu\nu}}$$

Example:

$$\mathcal{L}^{\mathrm{M}}(\mathcal{A}) = \frac{1}{4}F_{\mu\nu}F^{\mu\nu} = -\frac{1}{4}\mathrm{Tr}[F^2]$$

(Abelian Yang-Mills)

$$\Big\downarrow \; + \; \mathcal{O}_{\tau}^{[r,d]}$$

$$\mathcal{L}_g^{\mathbf{MBI}}(\mathcal{A},\tau) = \frac{-\sqrt{|\det\left[g_{\mu\nu}\right]|} + \sqrt{\det\left[g_{\mu\nu} + \sqrt{2\tau}F_{\mu\nu}\right]}}{2\tau}$$

(Born-Infeld nonlinear electrodynamic)

The perturbing operator can be written in the following form:

$$\mathcal{O}_\tau^{[r,d]} = \frac{1}{d}\widehat{T}_{\tau,\mu\nu}T_\tau^{\mu\nu}$$

Where we have introduced

$$\widehat{T}_{\tau,\mu\nu} := f_{\mu\nu\rho\sigma}T_\tau^{\rho\sigma} = r g_{\mu\nu}\mathrm{tr}[\mathbf{T}_\tau] - T_{\tau,\mu\nu}$$

and

$$f_{\mu\nu\rho\sigma} := r\, g_{\mu\nu}g_{\rho\sigma} - g_{\mu\sigma}g_{\nu\rho}$$

Then, it is possible to prove that

Dynamically equivalent

$$\begin{cases} \mathcal{A}_{\tau+\delta\tau}(g_{\mu\nu}) \simeq \mathcal{A}_\tau(g_{\mu\nu}(\tau+\delta\tau)) \\ \dfrac{\mathrm{d}g_{\mu\nu}}{\mathrm{d}\tau} = -\dfrac{4}{d}\widehat{T}_{\tau,\mu\nu} \end{cases}$$

One can integrate the flow equation for the metric and find -in principle- the deformed metric

TTbar deformed matter coupled to Einstein gravity

↕

Standard matter coupled to modified gravity

$$S_{\mathrm{EiBI}}[g_{\mu\nu}] + S_{\mathrm{Max}}[g_{\mu\nu}] \simeq S_{\mathrm{EH}}[h_{\mu\nu}] + S_{\mathrm{MBI}}[h_{\mu\nu}]$$

↕

$$\frac{1}{\tau}\int \mathrm{d}^4x \left[\sqrt{-\det\left(g_{\mu\nu} + \tau\mathcal{R}_{(\mu\nu)}(\Gamma)\right)} - \sqrt{-g}\right]$$

(Eddington-inspired Born-Infeld (EiBI) gravity)

THANK YOU FOR YOUR ATTENTION!